

# CODE's multi-GNSS orbit and clock solution - status 2016

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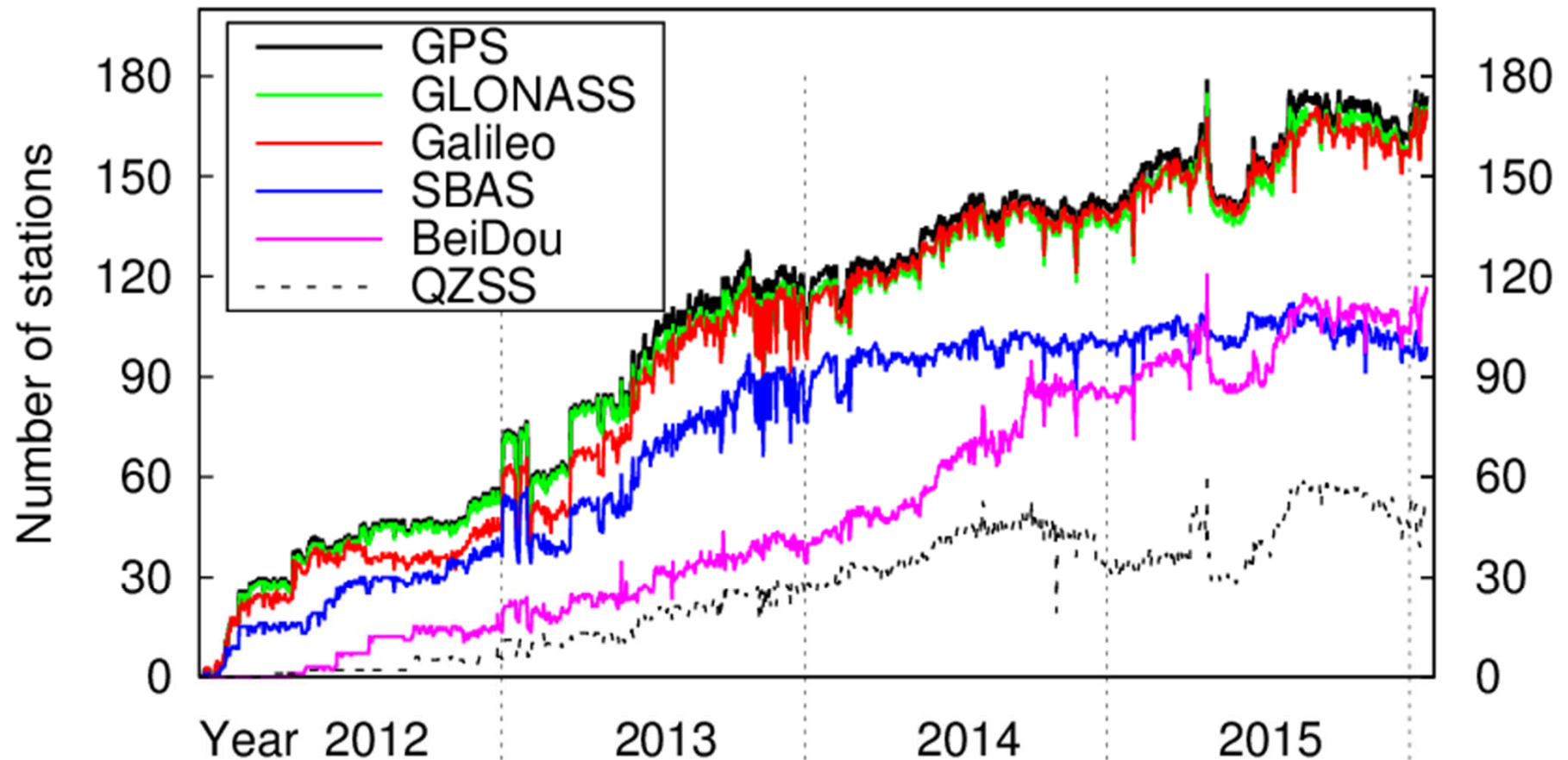
# Contents

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- Data base and network
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# MGEX data monitoring

Number of stations providing daily RINEX3 files and included in CODE's raw data monitoring (data sources: IGS-MGEX and EPN)



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# CODE MGEX orbit solution

GNSS considered:	GPS + GLONASS + Galileo + BeiDou (MEO+IGSO) + QZSS ( $\approx 70$ SV)
Processing mode:	Post-processing ( $\approx 2$ weeks latency)
Timespan covered:	GPS-weeks 1689 - today
Number of stations:	130 (GPS), 110 (GLONASS), 85 (Galileo); 55 (BeiDou); 20 (QZSS)
Processing scheme:	Double-difference network processing (observable: phase double differences)
Signal frequencies:	L1+ L2 (GPS + GLO+ QZSS); E1 (L1) + E5a (L5) Galileo; B1 (L1) + B2 (L7) BeiDou
Orbit characteristic:	3-day long arcs; SRP: ECOM / ECOM2 (since 2015)
Reference frame:	IGS08 (until week 1708); IGB08 (since week 1709)
IERS conventions:	IERS2003 (until 1705); IERS2010 (since 1706)
Product list:	Daily orbits (SP3) and ERPs
Distribution:	<a href="ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/">ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/</a> and <a href="ftp://ftp.unibe.ch/aiub/CODE_MGEX/">ftp://ftp.unibe.ch/aiub/CODE_MGEX/</a>
Designator:	comwwwwd.???.Z

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# CODE MGEX clock solution

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GNSS considered:	GPS + GLONASS + Galileo + BeiDou + QZSS ( $\approx 70$ SV)
Processing mode:	Post-processing ( $\approx 2$ weeks latency)
Timespan covered:	GPS-weeks 1710 - today
Number of stations:	130 (GPS), 35 (GLO), 45 (Galileo); 50 (BeiDou); 20 (QZSS)
Processing scheme:	<b>Zero-difference</b> processing (observable: code+phase undifferenced)
Signal frequencies:	L1+ L2 (GPS + GLO+ QZSS); E1 (L1) + E5a (L5) Galileo; B1 (L1) + B2 (L7) BeiDou
A priori information:	Orbits, ERPs, coordinates, and troposphere from CODE MGEX orbit solution introduced as known
Reference frame:	IGb08
IERS conventions:	IERS2010
Product list:	Epoch-wise (300s) satellite and station clock corrections in daily clock RINEX files; daily inter-system biases for mixed stations in Bernese DCB and BIAS-SINEX format <a href="ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/">ftp://cddis.gsfc.nasa.gov/gnss/products/mgex/</a> and <a href="ftp://ftp.unibe.ch/aiub/CODE_MGEX/">ftp://ftp.unibe.ch/aiub/CODE_MGEX/</a>
Distribution:	

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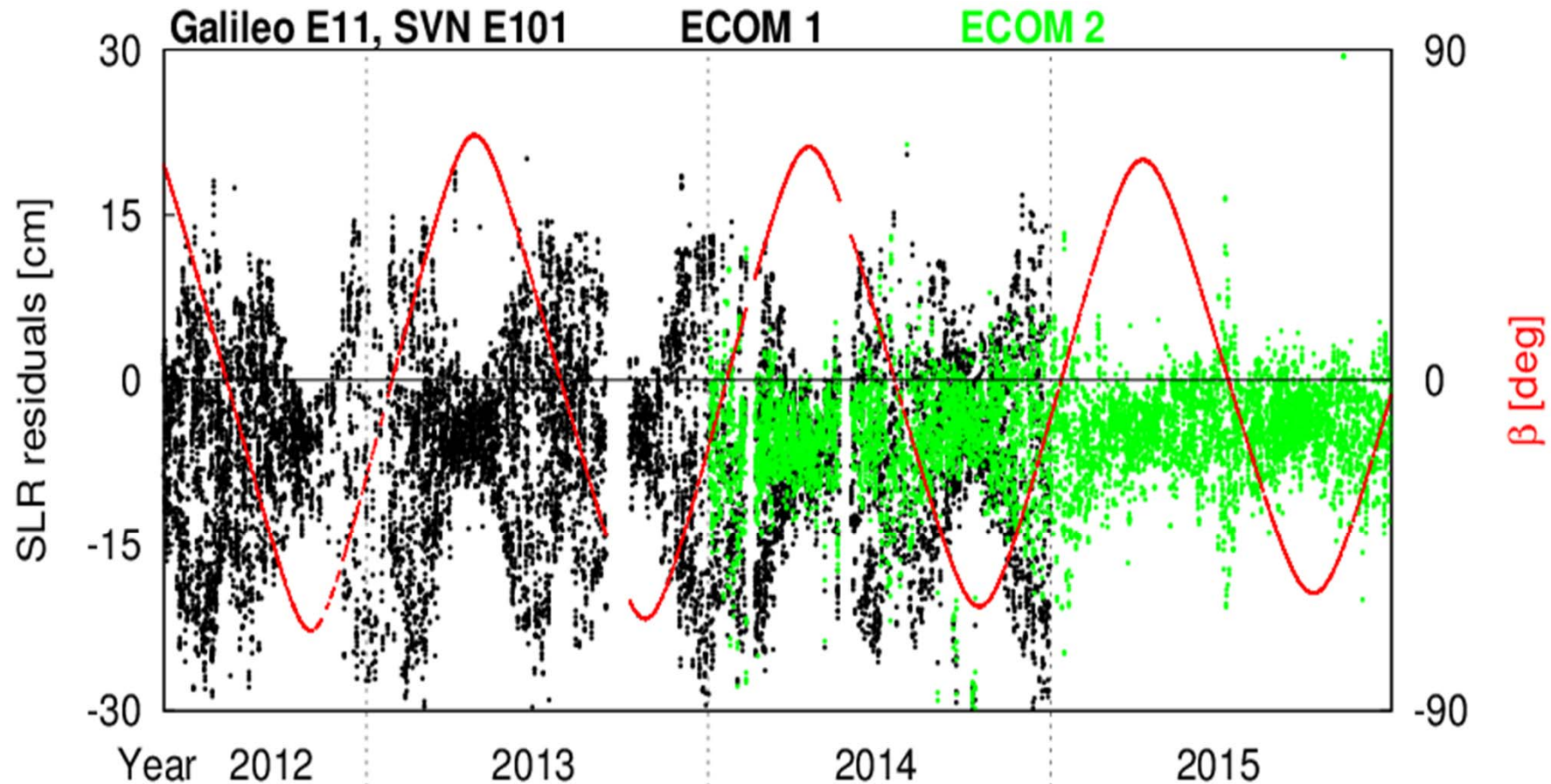


# Changes w.r.t. to IGS solution

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- Implementation of Galileo, QZSS, BeiDou (except GEOs)
- Use of RINEX3 files from MGEX network; selection of observation types
- Improved SRP model for yaw-steering attitude (ECOM2, Arnold et al., 2015)
- Normal attitude and related SRP models for QZSS and BeiDou
- ANTEX (PCO+PCV) for Galileo, QZSS, BeiDou
- Attitude laws for GPS, GLONASS, (Galileo?) eclipses
- Proper handling of observation biases
- Ambiguity resolution for Galileo, BeiDou, QZSS
- Albedo radiation modelling for Galileo, QZSS, BeiDou
- Antenna thrust for (GLONASS), Galileo, QZSS, BeiDou

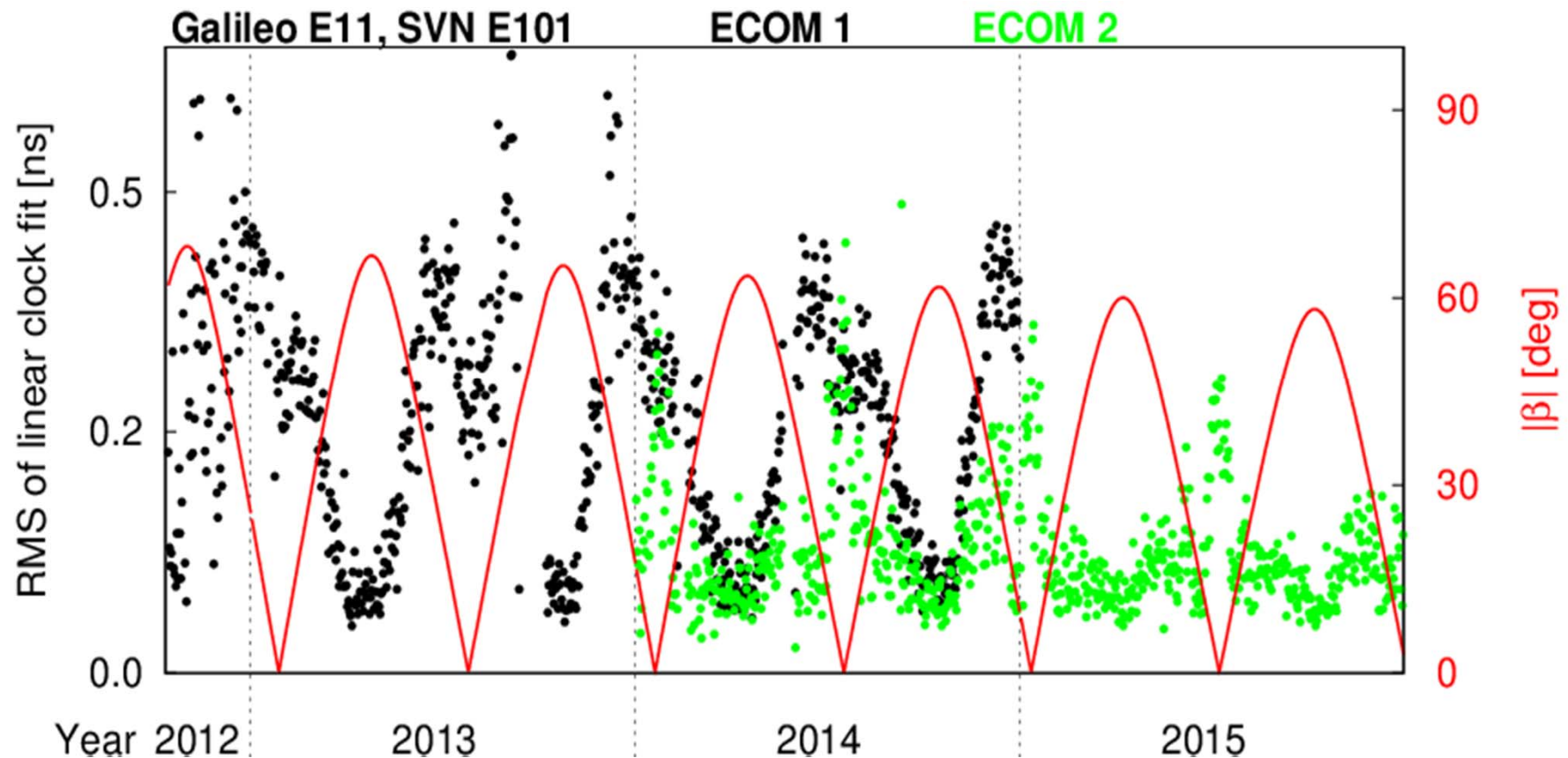
# Galileo orbit validation



⇒ Significant reduction of dependency on beta-angle, when changing to the ECOM2 (attitude related?)



# Galileo clock validation



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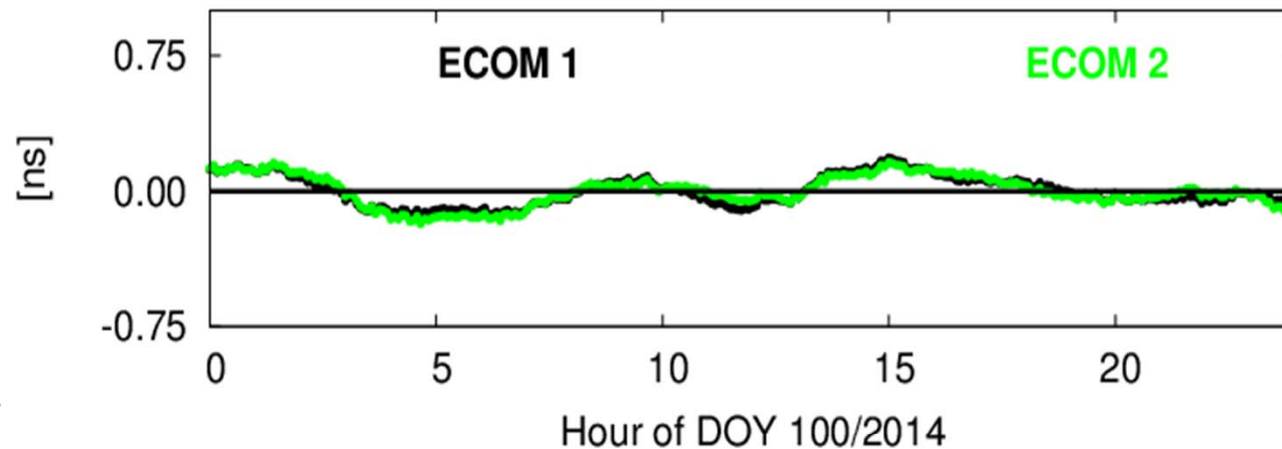
- ⇒ Significant reduction of dependency on beta angle
- ⇒ Pronounced signal remains during eclipse season or close-by (attitude related?)





# Galileo clock validation

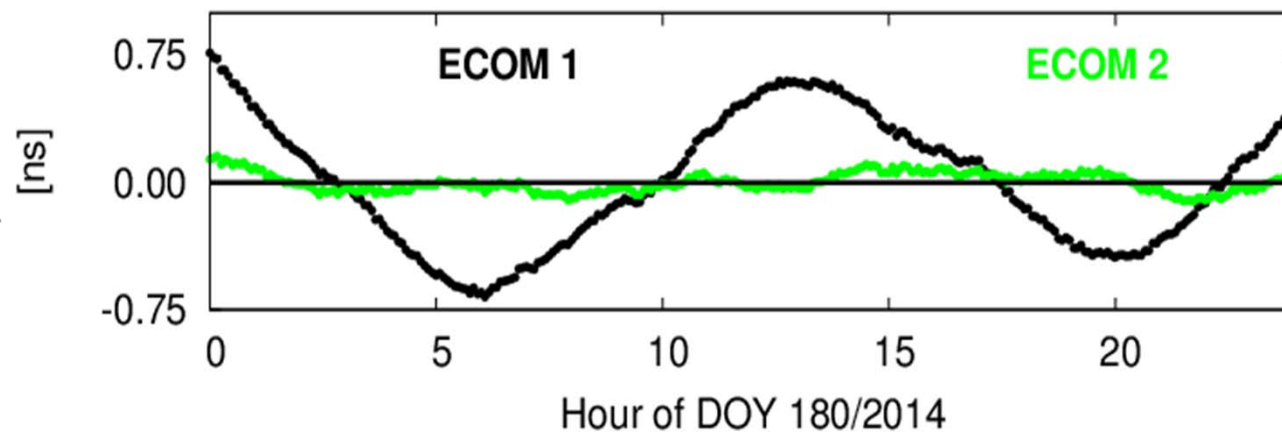
Clock corrections of Galileo E11, SVN E101



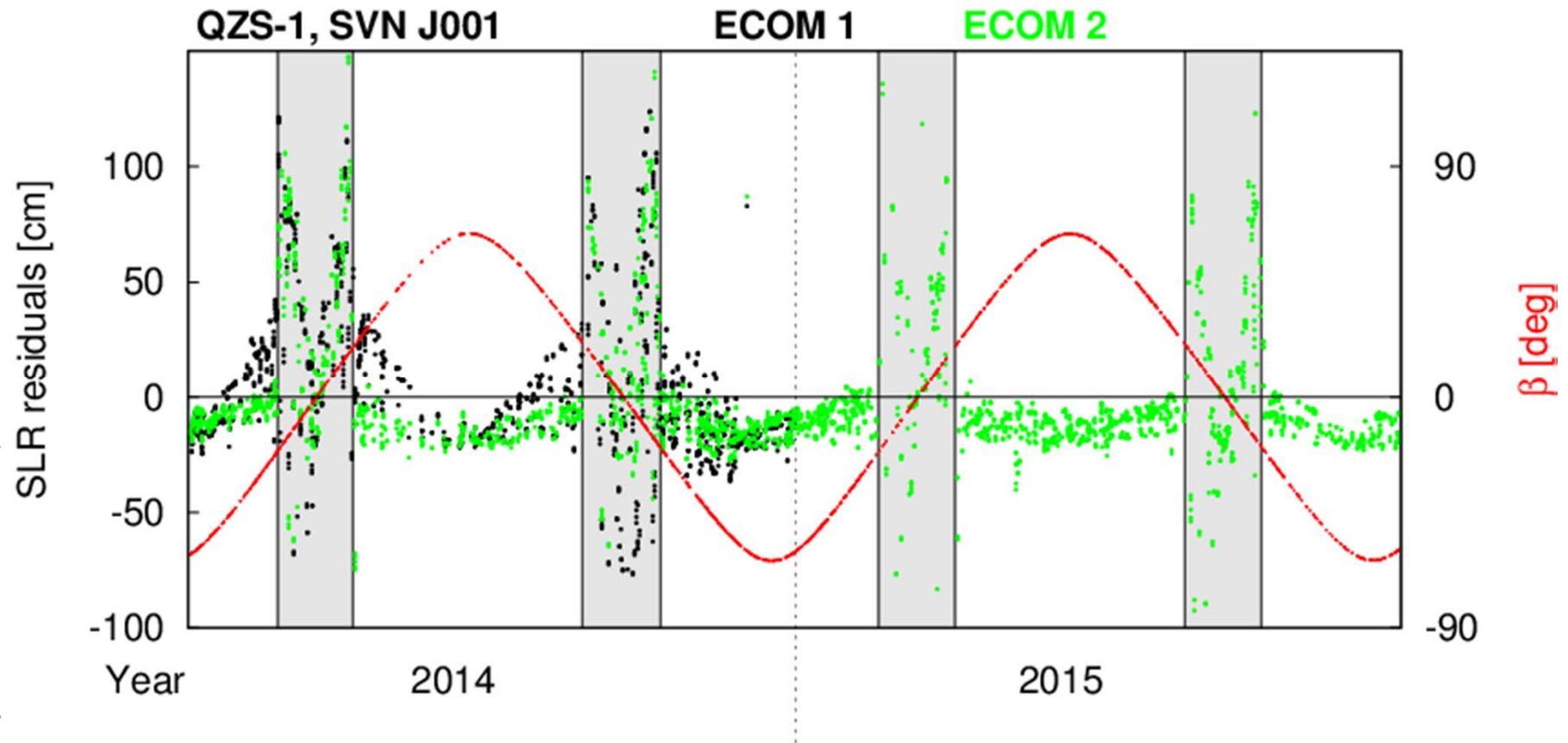
Large beta-angle:  
=> Clock signal has  
small amplitude  
(about  $\pm 0.15$  ns)

Small beta-angle:  
=> Periodic signal  
caused by mis-  
modelled orbit  
(ECOM1)

=> Significant reduction  
of signal amplitude  
from  $\pm 0.75$  ns to  
 $\pm 0.15$  ns when  
switching to  
**ECOM2**

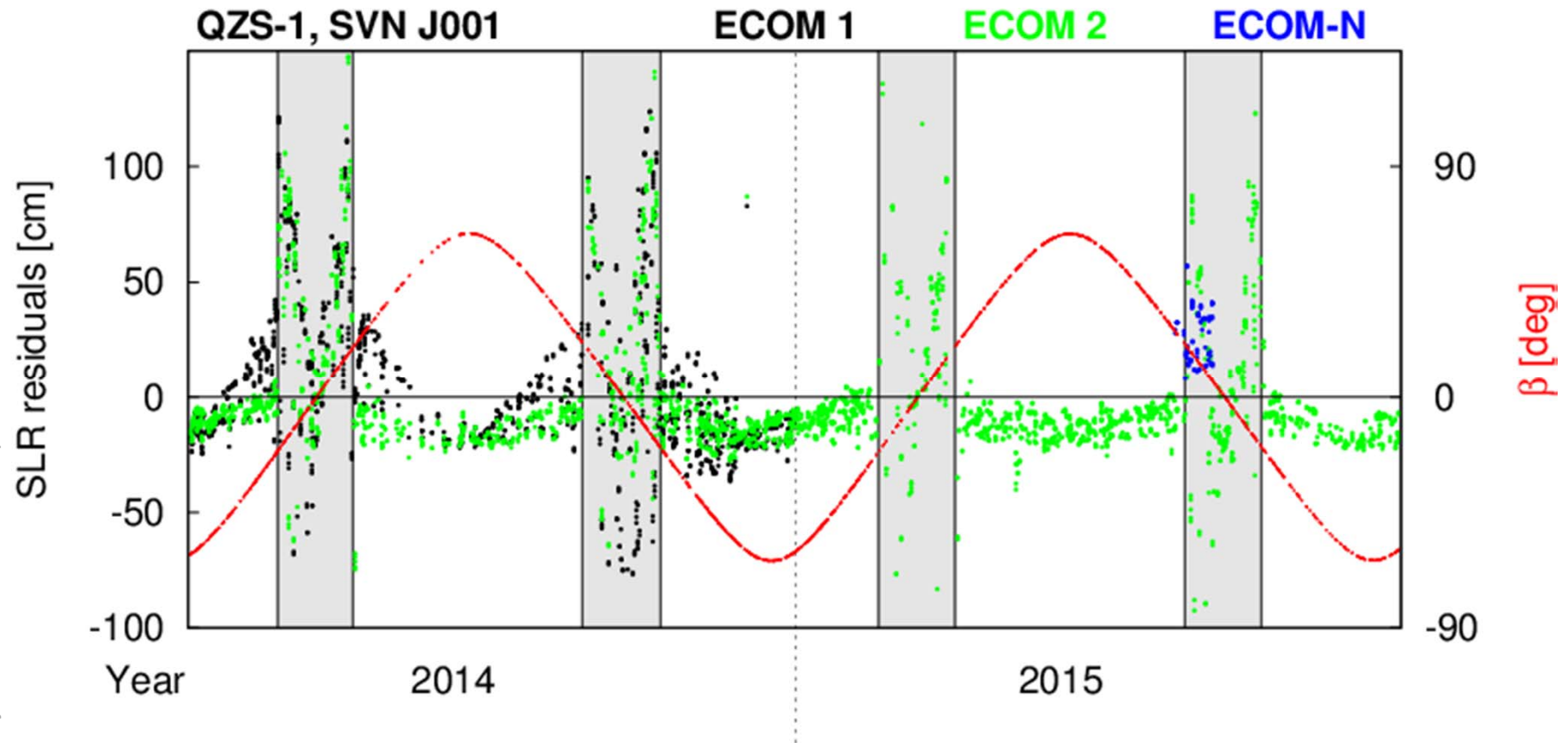


# QZSS orbit validation



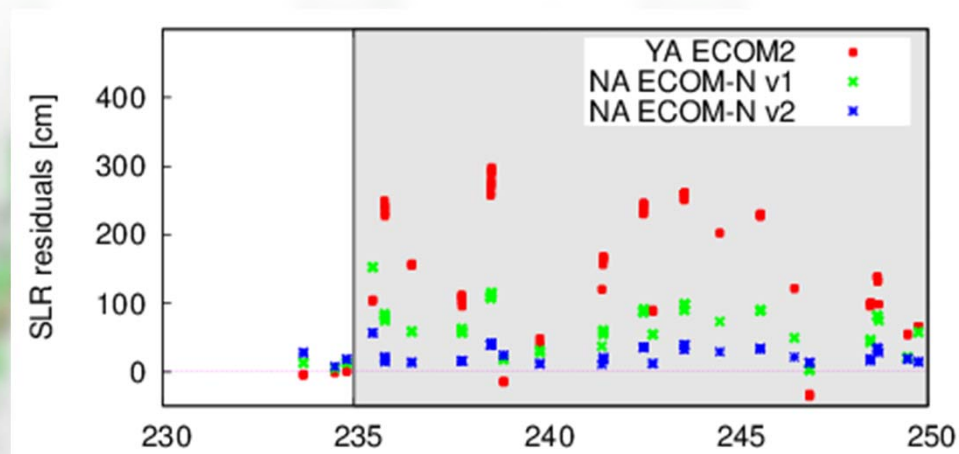
- ⇒ Yaw-steering: ECOM2 reduces dependency on beta angle
- ⇒ Significant SLR offset remains

# QZSS orbit validation



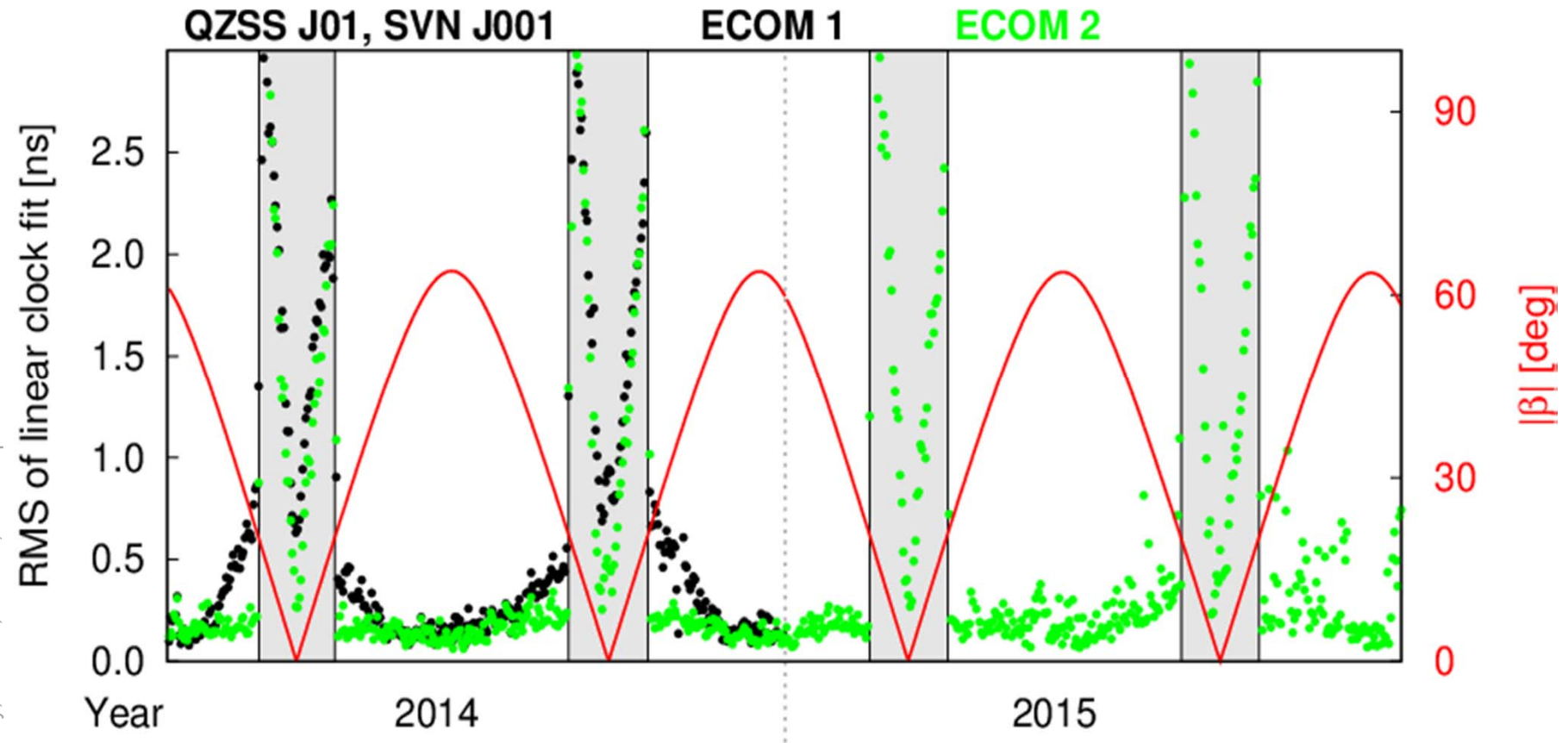
- ⇒ Normal attitude mode ( $|\beta| < 20^\circ$ ; marked grey): large orbit errors
- ⇒ Test of new ECOM versions suited for orbit normal attitude mode

# QZSS orbit validation



⇒ Test of new ECOM versions suited for orbit normal attitude mode

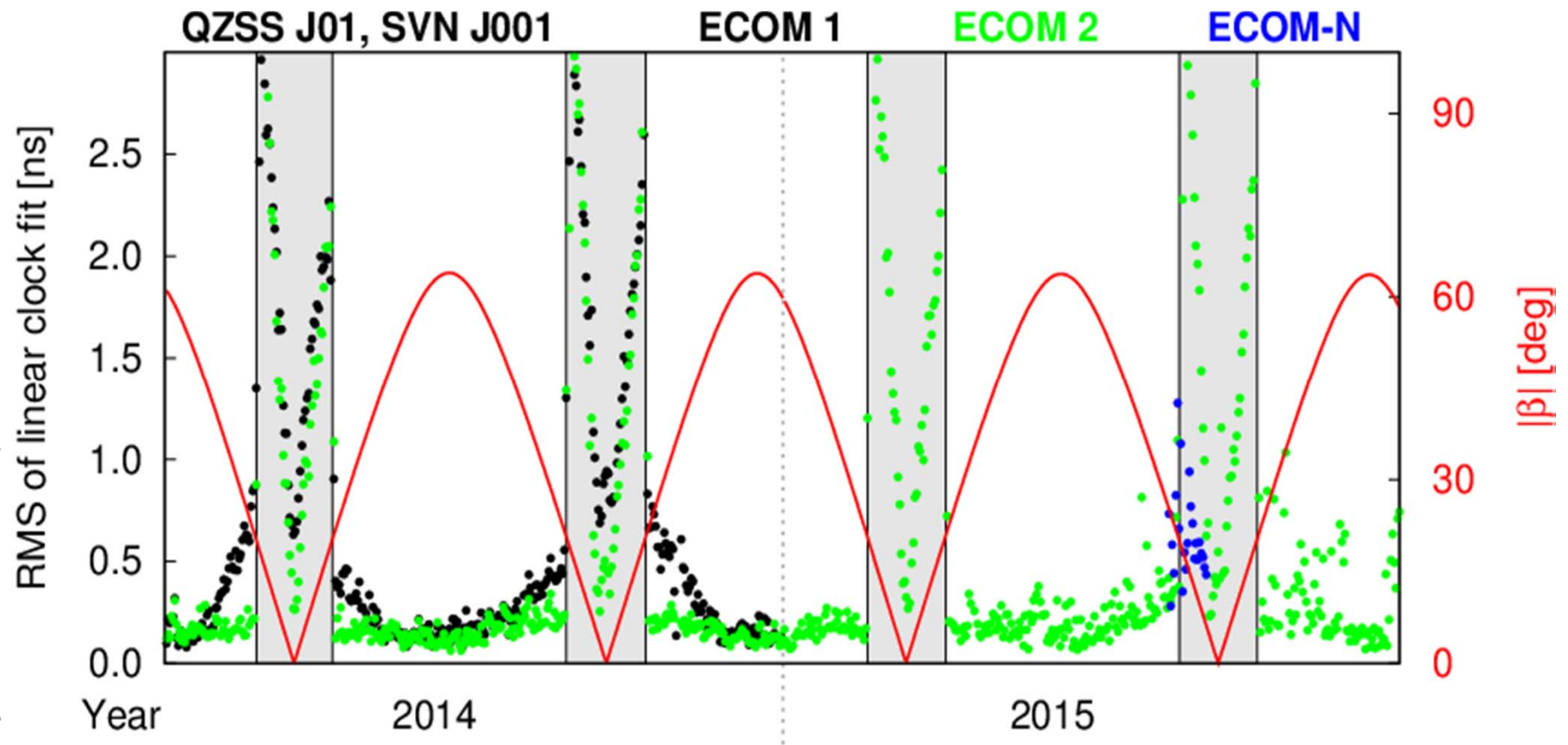
# QZSS clock validation



- ⇒ Yaw-steering: significant reduction of dependency on beta angle thanks to ECOM2
- ⇒ Orbit normal attitude mode (grey): large errors remain



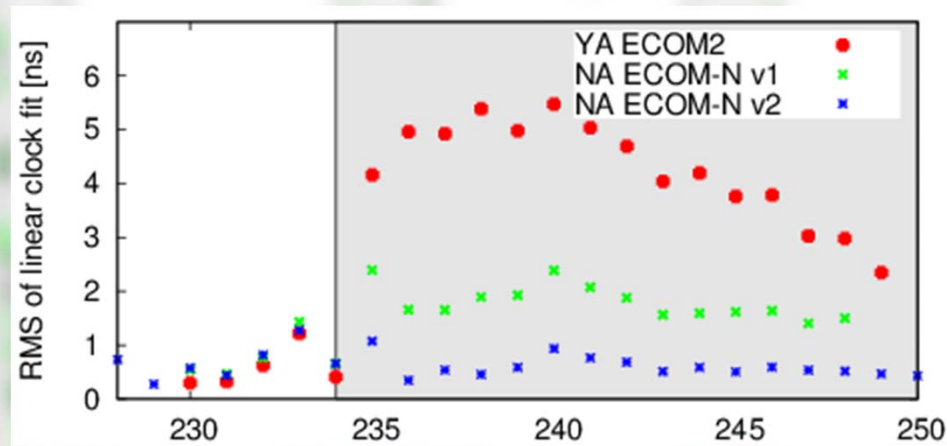
# QZSS clock validation



⇒ Experiments with ECOM versions better suited for orbit normal attitude mode

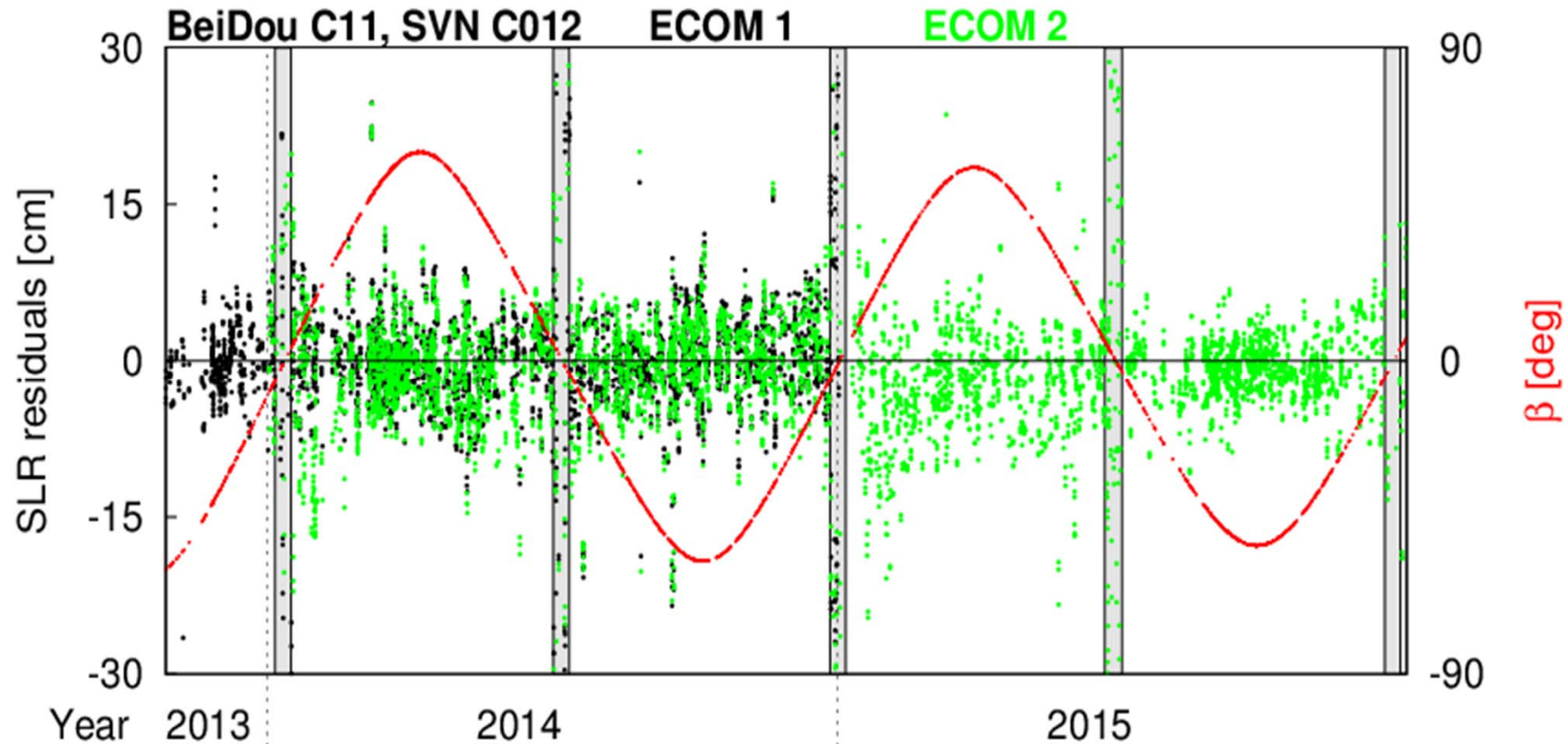


# QZSS clock validation



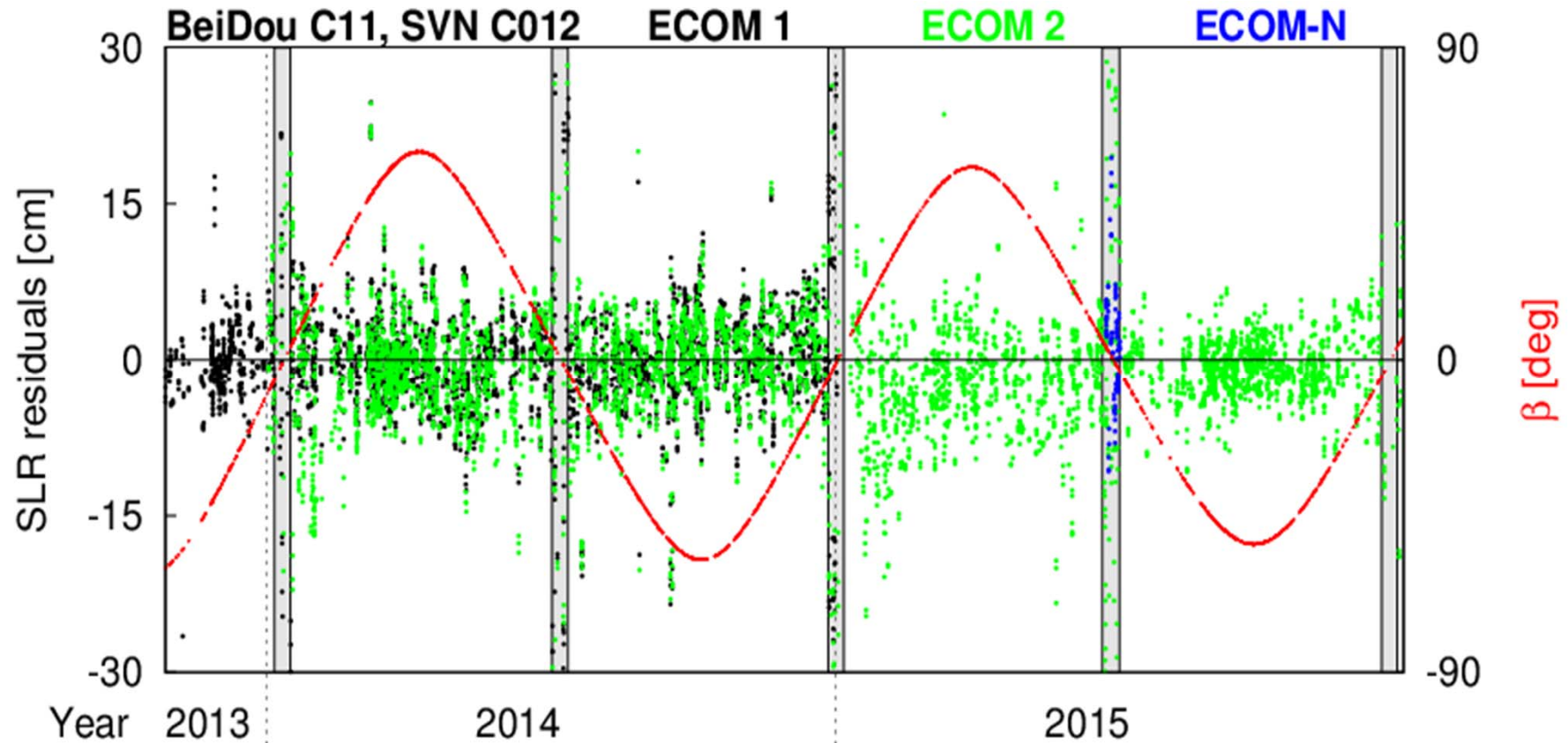
⇒ Experiments with ECOM versions better suited for orbit normal attitude mode

# BeiDou orbit validation



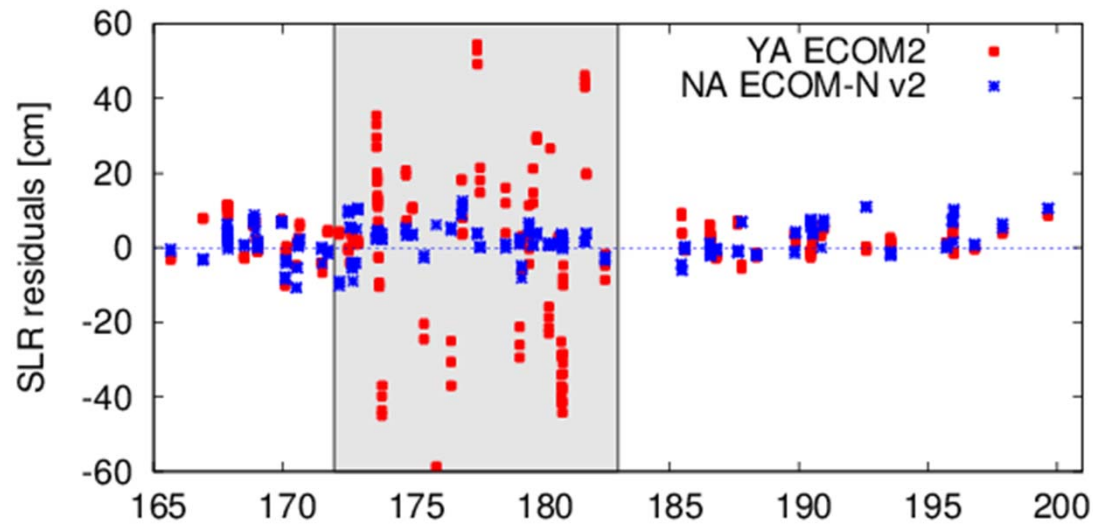
- ⇒ Yaw-steering: no significant impact of ECOM version
- ⇒ Orbit normal attitude mode ( $|\beta| < 4^\circ$ ; grey boxes; not correctly considered): large residuals

# BeiDou orbit validation



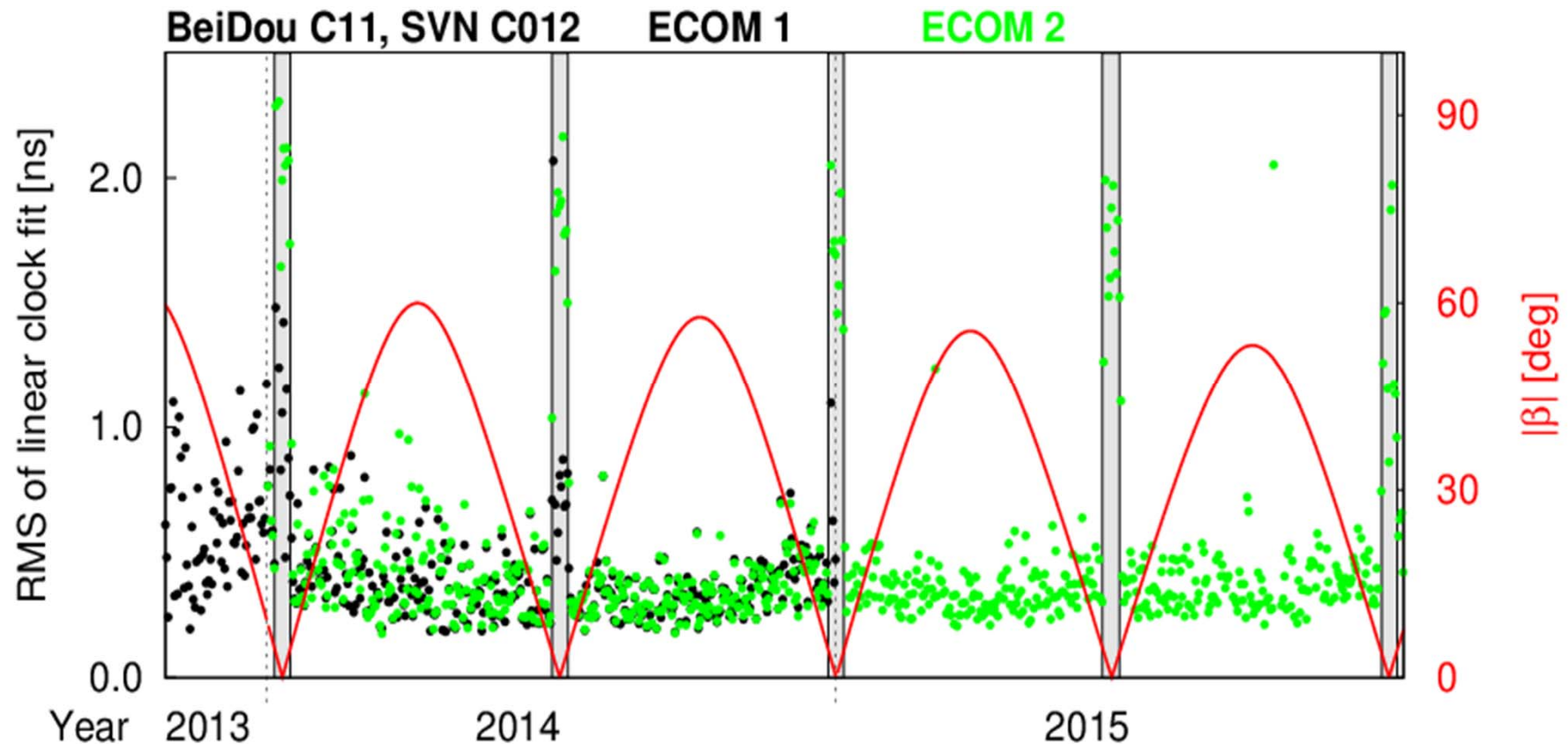
⇒ Test of new ECOM versions better suited for orbit normal attitude mode

# BeiDou orbit validation



⇒ Test of new ECOM versions better suited for orbit normal attitude mode

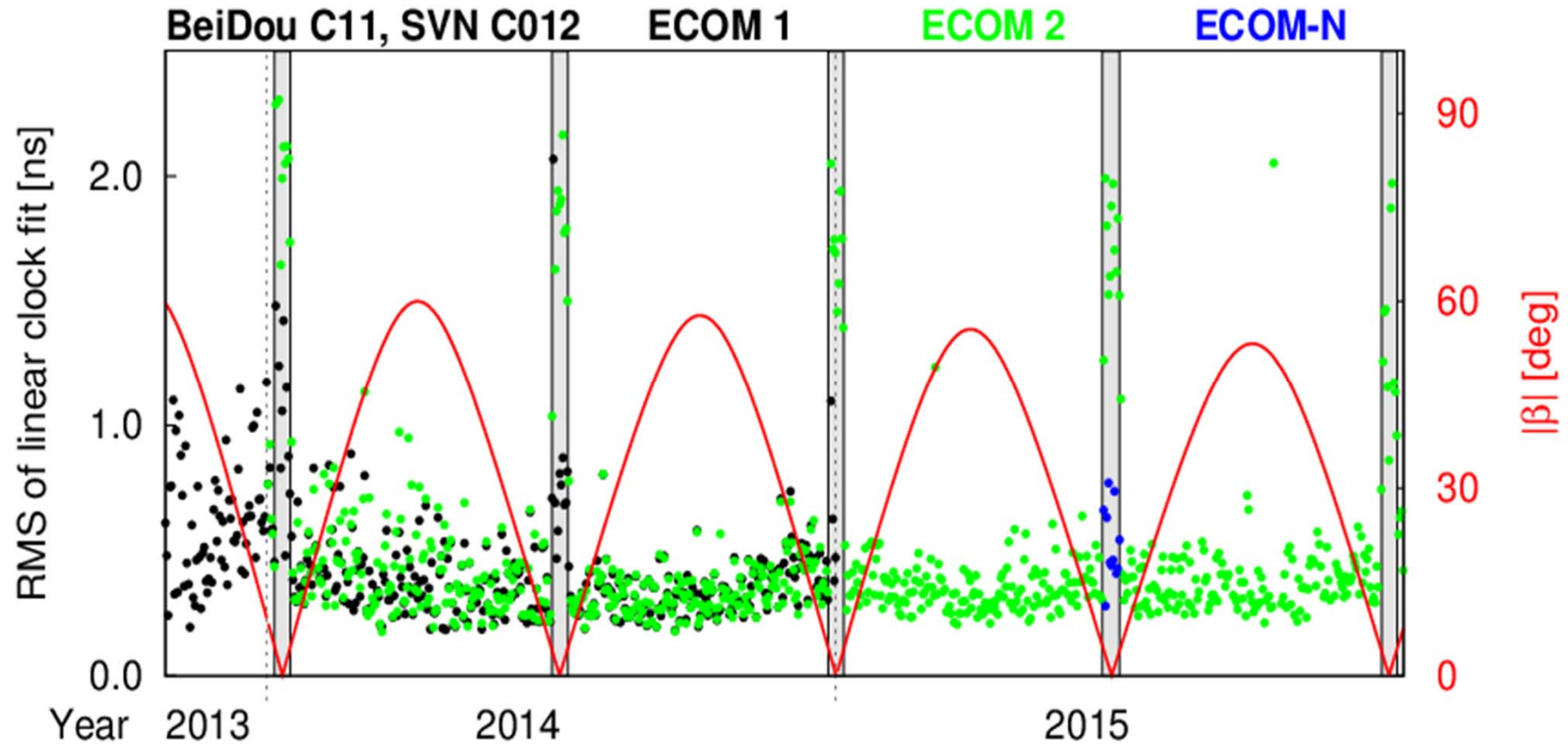
# BeiDou clock validation



- ⇒ Yaw-steering: no significant difference between ECOM versions
- ⇒ Orbit normal attitude mode ( $|\beta| < 4^\circ$ , marked grey; wrong attitude considered): ECOM2 may even degrade solution



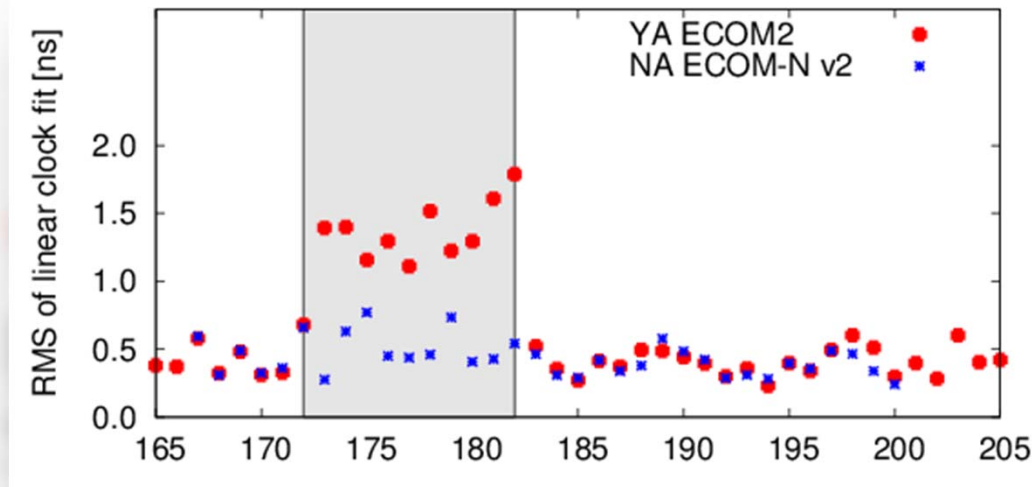
# BeiDou clock validation



⇒ Experiments with ECOM versions better suited for orbit normal attitude mode



# BeiDou clock validation



⇒ Experiments with ECOM versions better suited for orbit normal attitude mode

# Summary

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- Still a long way to go until new GNSS can contribute to CODE's IGS solutions with the same quality as GPS
- Our current focus: correct consideration of orbit normal attitude (challenges are, e.g., SRP modelling, detection and consideration of mode-transitions, ...)
- Next: use of published or own estimated transmitter antenna phase center corrections for Galileo, BeiDou, and QZSS
- Reprocessing of data from 2015 planned

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Thank you  
for  
your interest!

